The displacement of the tracheal tube during robot-assisted radical prostatectomy
Chul Ho Chang, Hyun Kyu Lee and Soon Ho Nam

Background and objective Robot-assisted prostatectomy requires pneumoperitoneum in a steep Trendelenburg position, which may induce endobronchial intubation or accidental extubation. The aim of the study was to evaluate the effect of pneumoperitoneum in 30° Trendelenburg position on the displacement of the tracheal tube and to measure the changes in trachea length using fiberoptic bronchoscope.

Methods Thirty male patients scheduled for robot-assisted radical prostatectomy were enrolled. After induction of general anaesthesia, the distance between the vocal cords and the tracheal tube tip (ΔVCE) between the tracheal tube tip and the carina (ΔEC) and between the vocal cords and the carina (ΔVC) was measured using a fiberoptic bronchoscope before and 10 min after pneumoperitoneum in neutral position (T1 and T2, respectively), and 2 h after pneumoperitoneum in 30° Trendelenburg position (T3).

Results The ΔVC and ΔEC decreased significantly 10 min after pneumoperitoneum in neutral position (T2) and 2 h after pneumoperitoneum in Trendelenburg position (T3) compared with those before pneumoperitoneum in neutral position (T1) (all \( P < 0.001 \)). The changes in ΔVE were not statistically significant.

Conclusion The confirmation of the tracheal tube position is recommended after pneumoperitoneum in steep Trendelenburg position during robot-assisted prostatectomy because the displacement of the tracheal tube may result in endobronchial intubation due to shortening of the carina-to-tube tip distance.


Keywords: tracheal tube, pneumoperitoneum, robot-assisted radical prostatectomy, Trendelenburg position

Received 2 June 2009 Revised 7 September 2009 Accepted 2 October 2009

Introduction

Although laparoscopic surgeries have been replacing a variety of open procedures due to its advantages such as small incision, fast recovery and less pain, the laparoscopic radical prostatectomy has not been performed frequently due to its technical difficulty. However, with the recent introduction of da Vinci robot (Intuitive Surgical Inc., Mountain View, California, USA), which has the three-dimensional stereoscopic image and a freely flexible arm, the robot-assisted radical prostatectomy (RALP) is gaining popularity because it offers the advantage of easy accessibility, decreased blood loss and lower transfusion rates over open retropubic radical prostatectomy. However, RALP requires pneumoperitoneum in steep Trendelenburg position, which may induce endobronchial intubation or accidental extubation.

A previous study reported tracheal shortening during laparoscopic gynaecologic surgery, which creates pneumoperitoneum in 15–20° Trendelenburg position. As a pneumoperitoneum in 30° Trendelenburg position is routinely assumed during RALP, we hypothesized that RALP may increase the degree of displacement of the tracheal tube due to its steeper Trendelenburg position.

The aim of the study was to evaluate the effect of pneumoperitoneum in 30° Trendelenburg position on the displacement of the tracheal tube and to measure the changes in trachea length using fiberoptic bronchoscope.

Materials and methods

After institutional ethical research board approval, written informed consent was obtained from the patients. We enrolled 30 male patients with American Society of Anaesthesiologists (ASA) physical status I or II undergoing robot-assisted prostatectomy. Patients with a predicted or known difficult airway, upper airway infection, BMI of more than 35 kg m\(^{-2}\) or with a past history of surgery in upper airway were excluded from the study.

Glycopyrrolate 0.004 mg kg\(^{-1}\) was administered intravenously to decrease oral and tracheal secretions. Electrocardiogram, pulse oximetry and noninvasive blood pressure monitor were applied to the patient at operating room. After 61 min\(^{-1}\) of 100% O\(_2\) was applied with a face mask, intravenous remifentanil was infused at a rate of 0.25 μg kg\(^{-1}\) min\(^{-1}\). General anaesthesia was induced with propofol (1.5 mg kg\(^{-1}\)) and rocuronium bromide (0.9 mg kg\(^{-1}\)). Following the loss of patient’s consciousness and muscle relaxation, the tracheal intubation was performed. The tracheal tube (Hi-Lo; Mallinckrodt Medical, Athlone, Ireland) was secured fixed at 22 cm from the incisor to the tracheal tube tip. The anaesthesia was maintained with 11 min\(^{-1}\) of O\(_2\), 11 min\(^{-1}\) of air, 1.5–2.5 vol% of sevoflurane and 0.1–0.3 μg kg min\(^{-1}\) of remifentanil. The patients were ventilated with 8 ml kg\(^{-1}\) of tidal volume without positive end-expiratory pressure.
(PEEP), and the respiratory rate was adjusted to maintain 
$\text{ETCO}_2$ between 4.2 and 5.1 kPa.

After the induction of anaesthesia, a fiberoptic bronchoscope (Olympus LF-P; Olympus Optical Company, Tokyo, Japan) was inserted into the tracheal tube through a swivel connector (VYGON, Ecouen, France) in neutral position before creation of pneumoperitoneum (T1). With advancement of the fiberoptic bronchoscope at 0°, the distance was marked with tapes on the bronchoscope when the tip was positioned at the vocal cord, the tracheal tube tip and the carina to measure the distance between the vocal cords and tracheal tube tip (ΔVE), between the tracheal tube tip and carina (ΔEC) and between the vocal cords and carina (ΔVC). The ΔVE, ΔEC and ΔVC were also measured 10 min after the pneumoperitoneum in neutral position (T2) and 2 h after the pneumoperitoneum in 30° Trendelenburg position (T3). All the measurements were made at end-expiration period. The intraabdominal pressure during pneumoperitoneum was maintained at 15 mmHg.

On the basis of the assumptions of values of $\alpha$ equal to 0.05, $\beta$ equal to 0.2 and SD equal to 1.15, which were estimated from the previous similar report, the minimal sample size for detecting the significant difference in the depth of endotracheal tube of 1 cm was 27.

All data were expressed as mean ± SD. At each time point, changes in ΔVE, ΔEC and ΔVC were analysed using repeated measures analysis of variance (ANOVA) with Tukey correction for increased $\alpha$ error due to multiple testing. A value of $P$ less than 0.001 was considered statistically significant.

**Results**

The study was conducted in 30 male patients, whose mean ± SD height, weight and age were 169 ± 5 cm, 68 ± 5 kg and 66 ± 8 years, respectively.

The changes in airway distances is illustrated in Fig. 1. The changes in ΔVC and ΔEC were statistically significant. The ΔVC was significantly decreased at T2 and T3 compared with that at T1 (12.0, 10.7 and 11.0 cm, respectively, both $P < 0.001$). The ΔEC was also decreased significantly at T2 and T3 compared with that at T1 (3.7, 3.0 and 3.1 cm, respectively, both $P < 0.001$). There was no significant change in ΔVC and ΔEC at T3 from those at T2. The change in ΔVE was not statistically significant.

The displacement of the tracheal tube did not result in endobronchial intubation or incidental extubation in this study and no patient suffered any respiratory complications in the postoperative period.

**Discussion**

In this study, the shortening of the carina-to-tube tip distance was observed during pneumoperitoneum, but upward displacement of the tracheal tube during steep Trendelenburg position was not observed.

Previous studies on the position of the tracheal tube reported that the tracheal tube could be displaced toward the carina after the pneumoperitoneum in Trendelenburg position. In this study, the tracheal shortening occurred after pneumoperitoneum, but adding Trendelenburg position, which was steeper than that applied during gynaecologic laparoscopy, did not aggravate the tracheal shortening. Other studies during laparoscopic surgeries also reported that the displacement of the tracheal tube mainly depends on the pneumoperitoneum rather than the position change.

The length of the trachea was defined as the distance between the vocal cords and the carina. This study demonstrated that the decrease in the carina-to-tube tip distance is responsible for the tracheal shortening during pneumoperitoneum because the distance between the vocal cords and the tube tip remained unchanged. This may be explained, in part, by the fact that the carina is connected to the lungs, which can easily be collapsed and shifted upward due to the pneumoperitoneum, whereas the upper part of the trachea is connected to the larynx, which is attached to the muscles and ligaments. Therefore, the tube should be placed at the mid-trachea during RALP to avoid bronchial migration of the tracheal tube.

Changes of the airway distance. Changes of the distance between vocal cord and carina (VC). Mean values are expressed as circle. Error bars indicate SD. Changes of the distance between vocal cord and tracheal tube tip (VE). Mean values are expressed as triangle. Error bars indicate SD. Changes of the distance between endotracheal tube tip and carina (EC). Mean values are expressed as square. Error bars indicate SD. Control, before pneumoperitoneum and Trendelenburg position; 10 min, 10 min after pneumoperitoneum; 2 h, 2 h after pneumoperitoneum and Trendelenburg position. EC, distance between the tracheal tube tip and the carina; VC, distance the vocal cords and the carina; VE, distance between the vocal cords and the tracheal tube tip. *$P < 0.001$ compared with control.
In this study, the displacement of the tracheal tube was seen 10 min after the pneumoperitoneum in supine position, but further displacement did not occur 2 h after the pneumoperitoneum in Trendelenburg position. Therefore, once the tracheal tube position was confirmed after creation of the pneumoperitoneum, the migration of the tracheal tube into the bronchus is an unlikely cause of the hypoxia or increased peak inspiratory pressure during RALP.

There are several limitations to this study. One of them is the lack of the control group because atelectasis following general anaesthesia may influence the tracheal shortening by inducing cephalad motion of the diaphragm and the lungs. Another limitation is the lack of measurement immediately after Trendelenburg position. However, as the degree of the tracheal shortening did not change 2 h after the pneumoperitoneum, which is known to worsen the atelectasis, it would not have affected the result of this study.

Conclusion
The confirmation of the tracheal tube position is recommended after pneumoperitoneum in steep Trendelenburg position during robot-assisted prostatectomy because the displacement of the tracheal tube may result in endobronchial intubation due to shortening of the carina-to-tube tip distance.

References